GE GLOBAL RESEARCH

Naval-Industry R&D Partnership Conference 2004

Jeff Slotnick

GE Global Research

Began in Schenectady, New York in 1900

Founded with the focus to improve businesses through technology

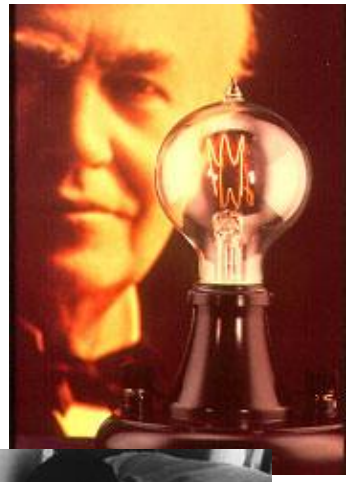
One of the world's most diverse industrial labs

Cornerstone of GE's commitment to technology

c. 1900

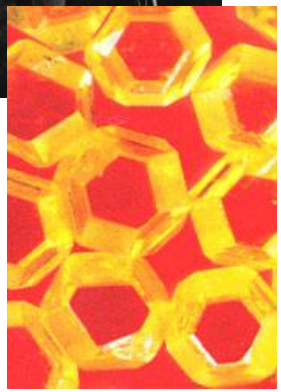
2004

100 Years of Material Science…



GE Innovations

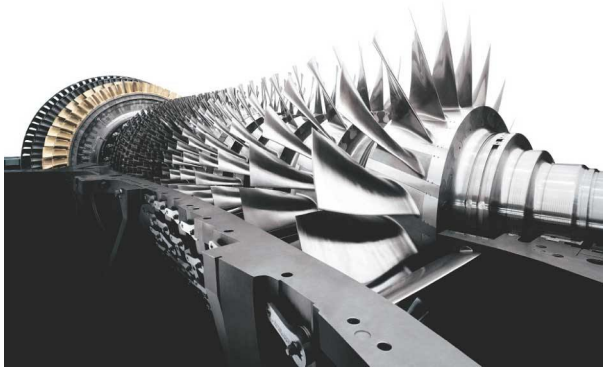
1909: Ductile Tungsten Filament
1913: First Medical X-Ray Tubes
1939: Non-Reflecting Glass
1946: Cloud Seeding
1953: Lexan® Polycarbonate
1955: Man-Made Diamonds
1962: Solid State Laser
1976: Fan Beam CT
1982: Ultem® High Performance Polymer
1988: Superconductivity for MRI
1999: Composite Fan Blade for Aircraft Engines
2000: Digital X-Ray



GE Has Always Been a Materials Company

11 Global Businesses

- Advanced Materials
- Commercial Finance
- Consumer Finance
- Consumer & Industrial
- Energy
- Equipment Services
- Healthcare
- Infrastructure
- Insurance
- NBC
- Transportation



The People

GE Technologists

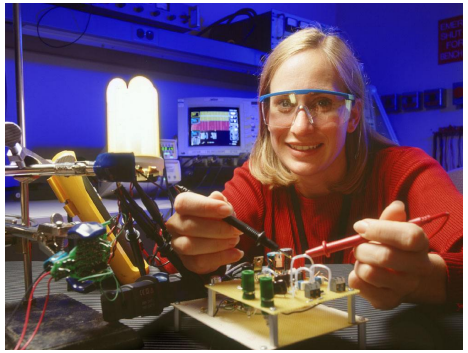
- 15,000+ Technologists Worldwide
- $2.6 Billion Annual R&D Spending

GE Global Research Technologists

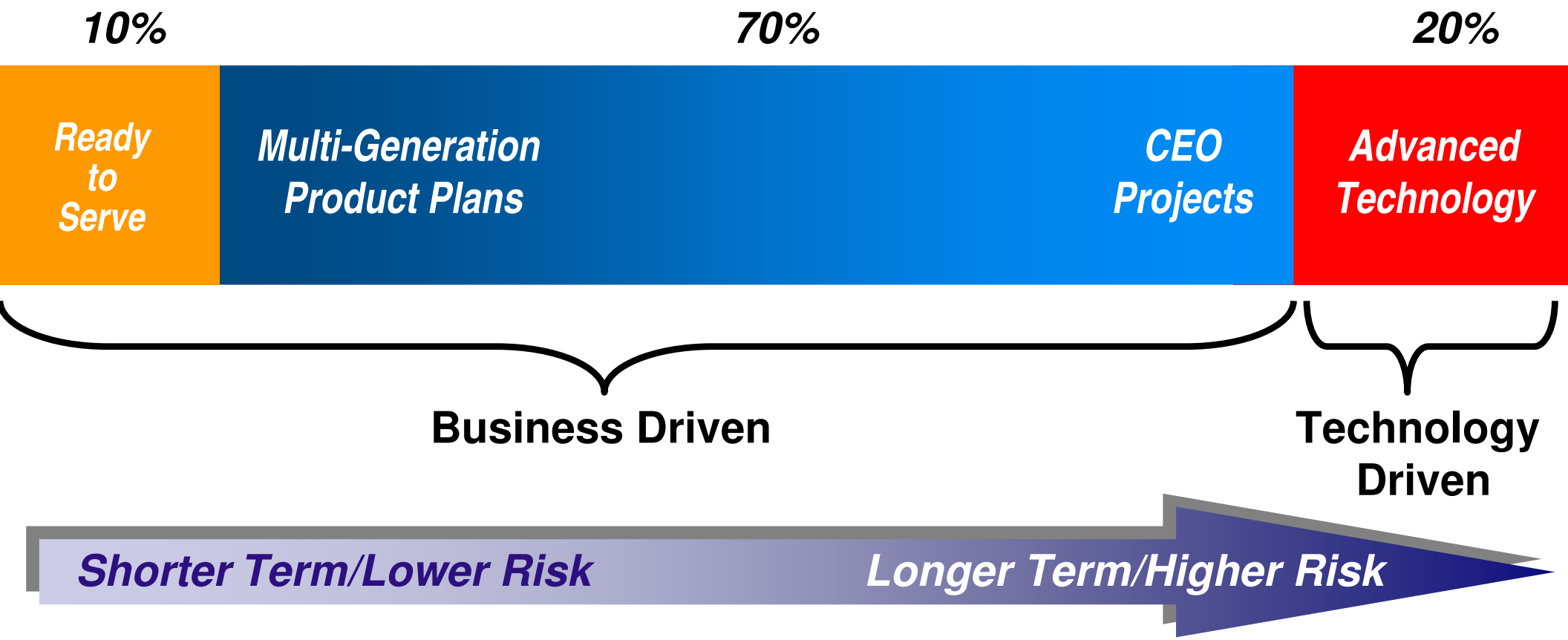
- 2,300 Technologists Worldwide
- $384 Million Annual R&D Spending

Technical Disciplines

- Chemistry
- Mech. Eng
- Physics
- Electrical Eng.
- Computer Science
- Metallurgy
- Biology
- Ceramics



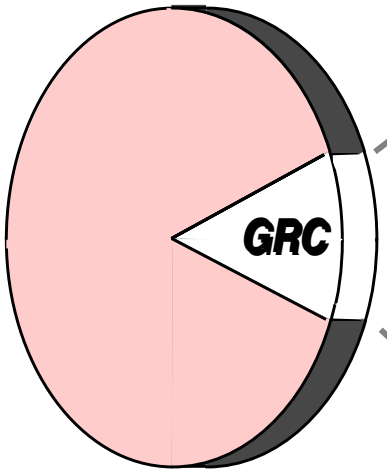
Investing in Technology

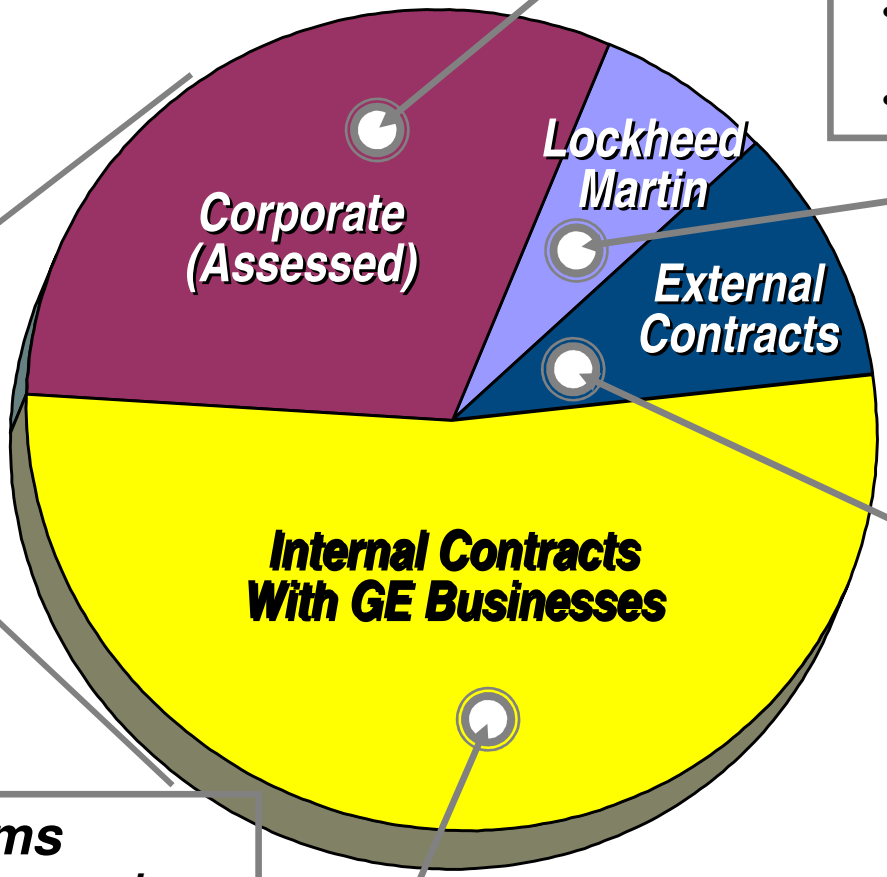


Funding Sources

GRC: ~$380MM

GE R&D: ~$2.6B





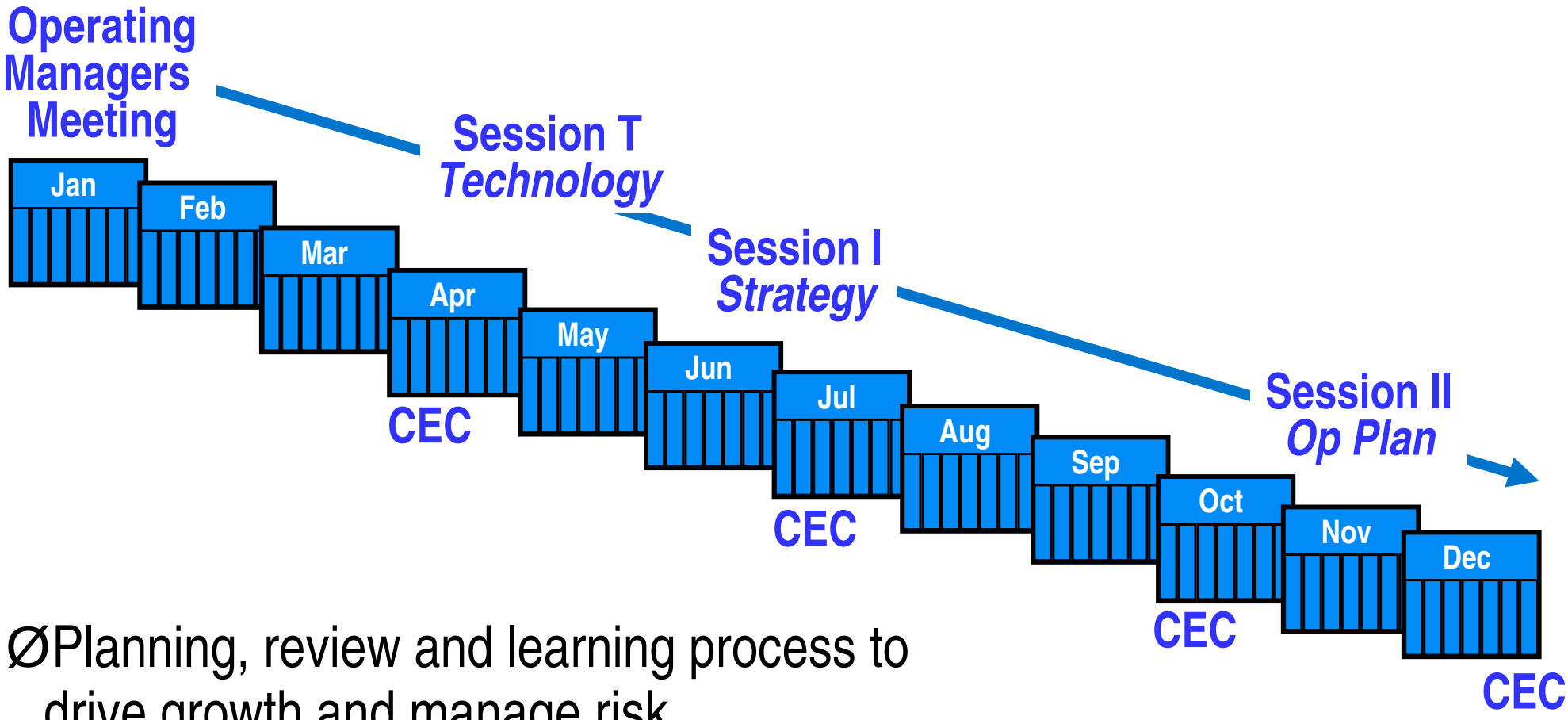
Assessed Programs
- CEO Programs (Fuel Cells, Wind, Next Gen CT, etc.)
- Advanced Technology (Bio, Nano, Photonics, etc.)
- MGPD Risk Reduction

Lockheed Martin
- Corporate "Shared Vision"
- Business Projects

External Contracts
- Share risk for advanced product technology
- Support GE business customer relationships
- Gov't (DoE, DoD, NIH, etc.)
- GE commercial customers

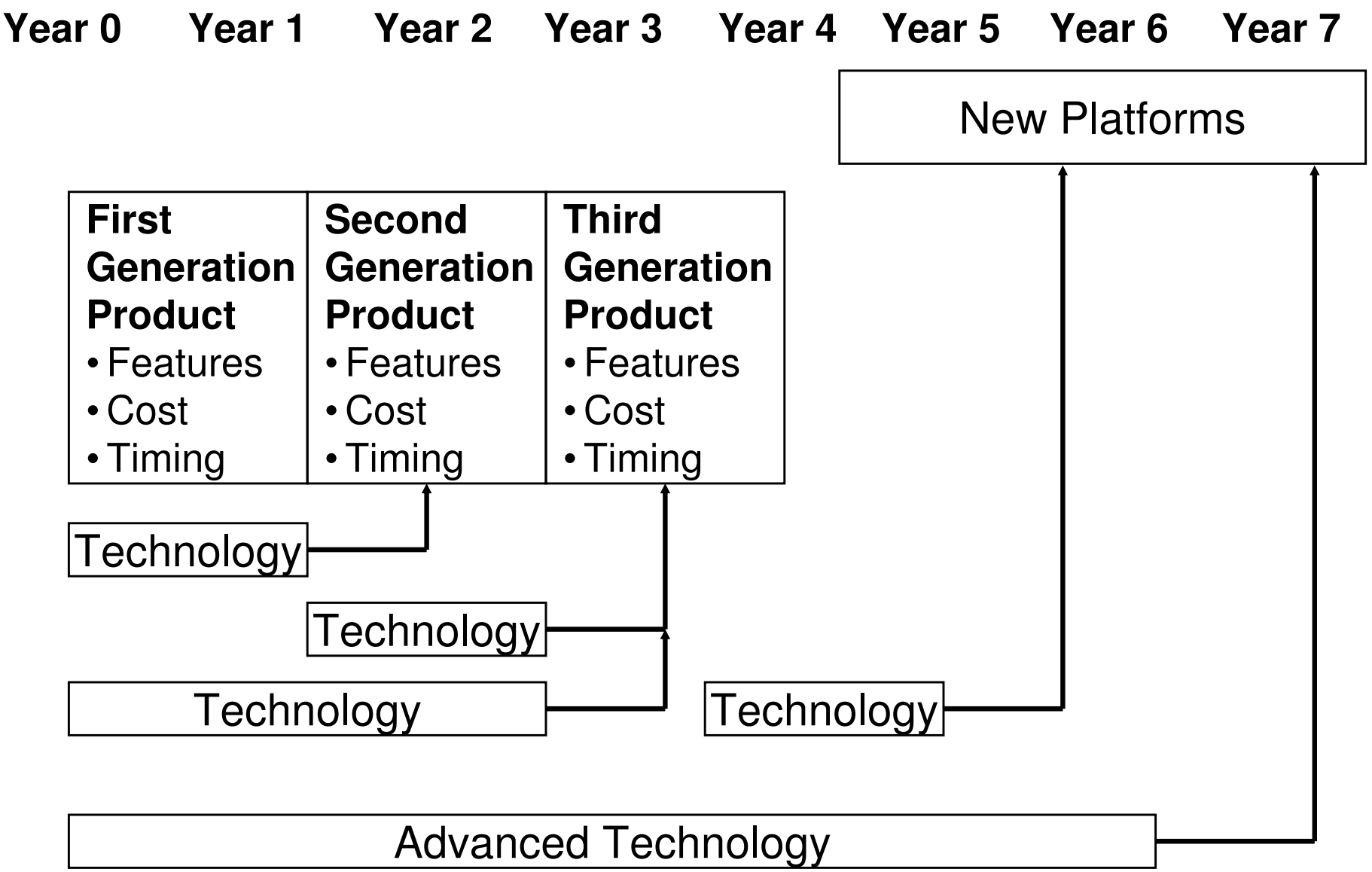
GE Business Programs
- Product / Process Development
- Productivity and Quality Programs
- Short Term Issues (RTS)

The GE "Operating System"



- Planning, review and learning process to drive growth and manage risk
- Uniform process followed by all GE businesses

Technology & Product Plans Coupled

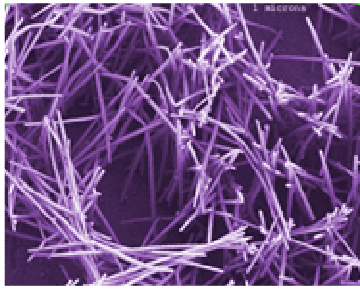


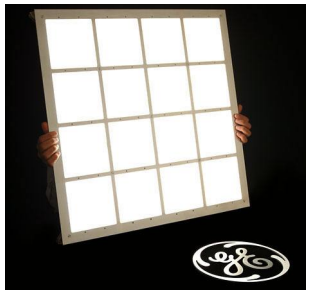
Advanced Technology Programs

Steady Progress of Key Long-term Programs:

Fuel Cells: Continuing research to make cells bigger, longer lasting, with higher power density. Increased oxidation resistance of metal interconnects by more than factor of ten; showed world-class power density on button cells.

Nanotechnology:
Nanotechnology: the "ultimate material science" - bringing property breakthroughs discovered in nanoaluminum to higher temperature metals for wider application in jet engines; initiated nanoceramics program for harsh environment sensors.

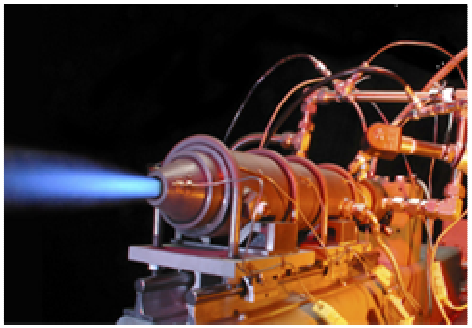


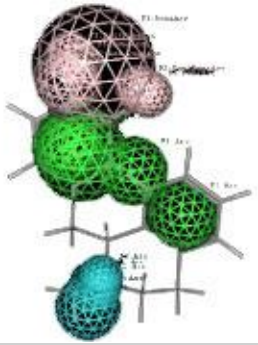


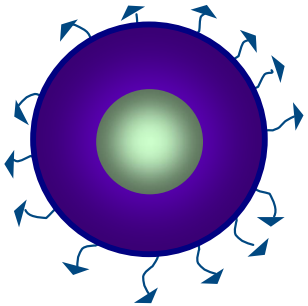
Light-Energy: Set world records in efficiency and light output for illumination quality OLEDs; leveraging technology to develop all-plastic photovoltaic technology.

Molecular Medicine:
Identified new biomarkers for specific disease states, and invented molecules to bind to the biomarkers. Currently in pre-clinical trials to evaluate effectiveness of these diagnostic pharmaceuticals.

Advanced Propulsion:
Pulsed detonation propulsion has potential to enable simpler and more efficient engines; demonstrated recent advances using aviation fuel; scaling up and targeting specific propulsion applications.



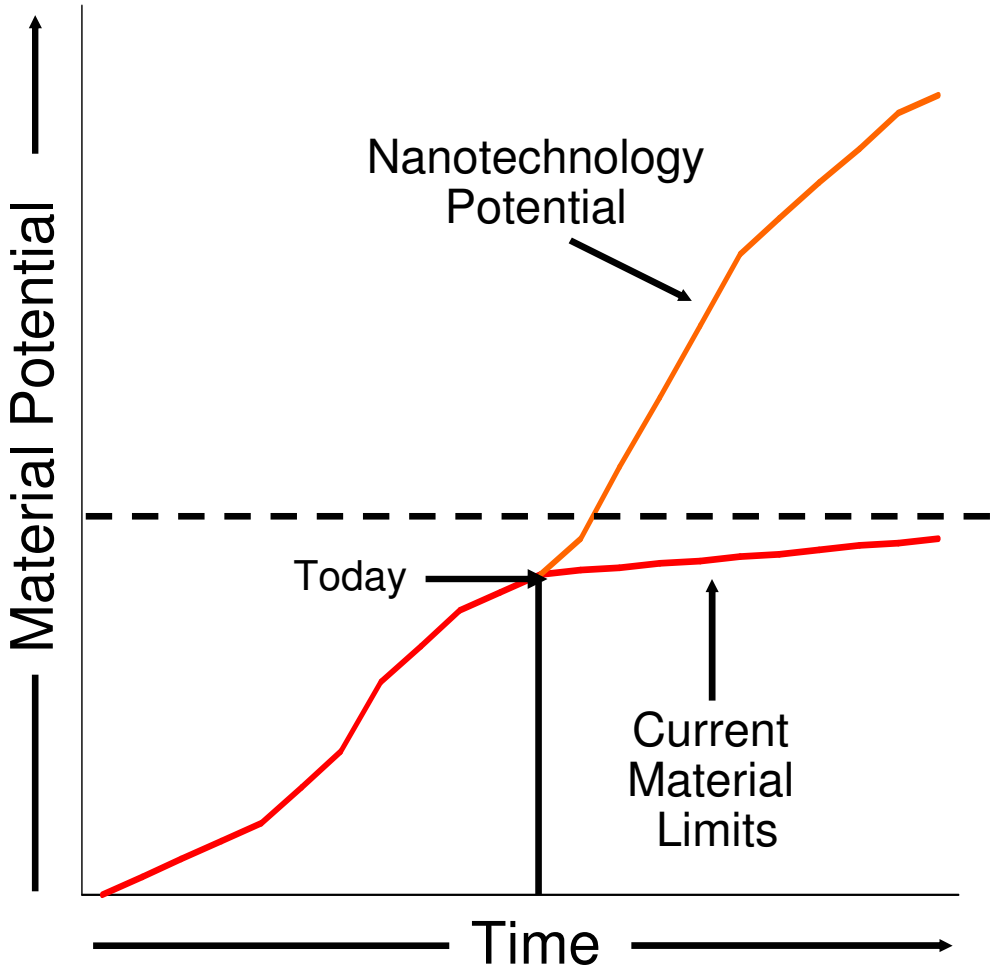




Nanotechnology for GE

The Ultimate Material Science…

- Potential to Impact Every GE Business
- Critical Enabling Technologies
- Creates a Step Change in Materials Technology



Nanotechnology AT

Vision

- 5-10+ years to impact Business
- Corporate & external funding
- Incubator for nanotechnology
- Focal point for nanotechnology projects across GRC

The Team

- ~50 PhD Scientists:

  Chemists, Physicists, Metallurgists, Ceramists,

  Chemical Eng, Mechanical Eng, Electrical Eng.

Platform Technology Focus

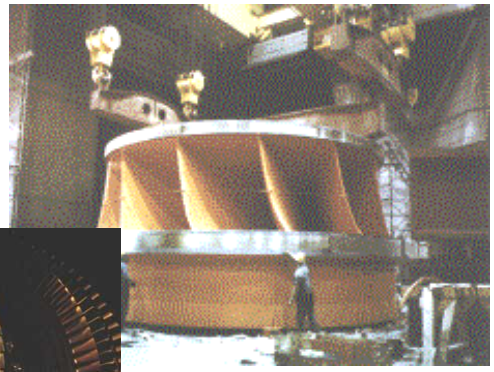
The Nanotechnology Platforms

NanoTubes and NanoRods

NanoParticles

NanoCeramics

NanoStructured Metal Systems



NanoTubes & NanoRods

Technology Emphasis:

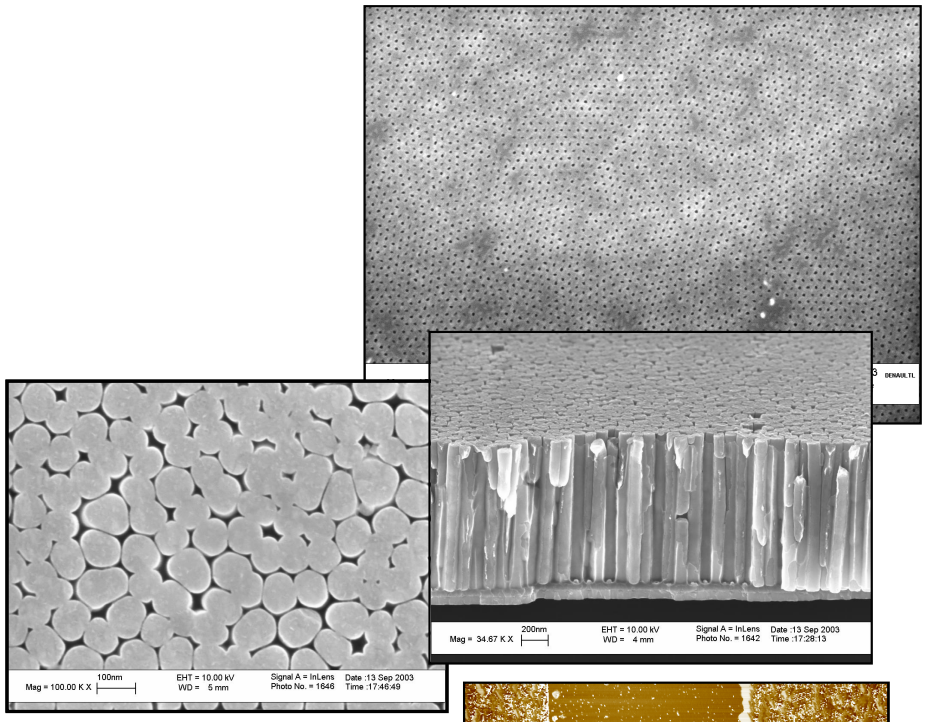
Synthesis & Ordering

- Synthesis of templates
- Synthesis of nanorods
  - –Electrochemical
  - –Laser deposition/VLS
  - –Chemical
  - –CVD
- Materials: Ni, Pt, Metal Carbides SWNT, MWNT

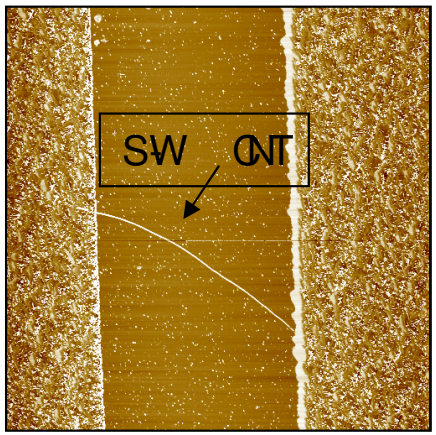
Device Integration

- Growth within device

Templates



Ni nanorods
(80nm dia)



NanoTubes & NanoRods

Product Impact:

Fluorescent Lighting

- Increased efficiency

Photovoltaics

- Cost-effective renewable power

Conductive Plastics

- Metal replacement applications

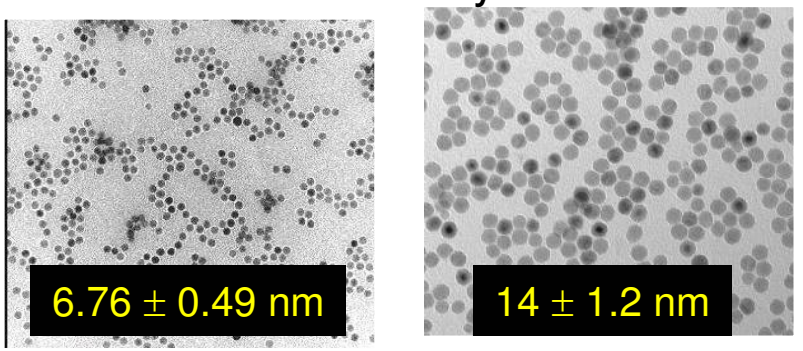
NanoParticles

Technology Emphasis:

NanoParticle Synthesis

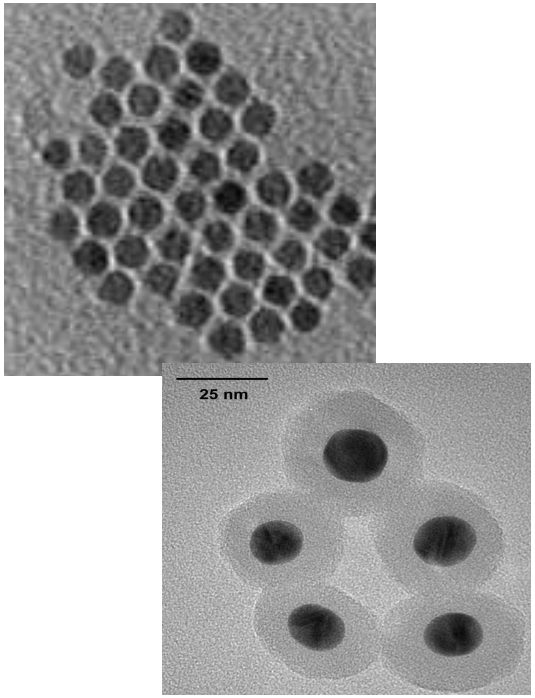
- Methods
  - –Solution: colloid, sol-gel
  - –Vapor
- Many material types

Controlled NanoParticle Synthesis



NanoParticle Functionalization

- Coatings/shell chemistry
  - –Surfactants
  - –Organic polymers
  - –Inorganic



Characterization

- Properties: magnetic, optical, biological
- Size/Shape: DLS, microscopy, zeta potential

NanoParticles

Product Impact:

Electronic Materials

- Thermal management for faster electronic devices
- Improved thermal conductivity
- Control CTE

Molecular Imaging

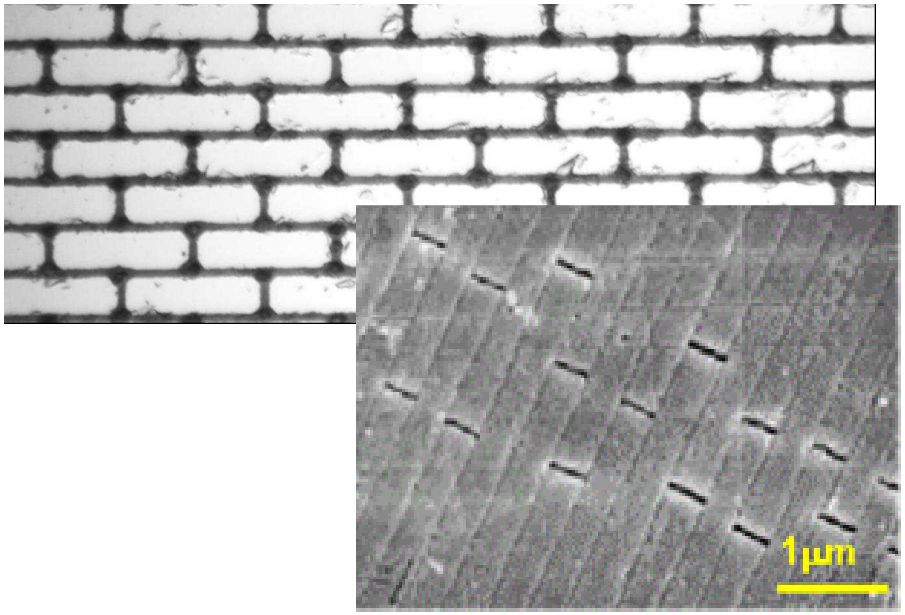
- Diagnosing disease before symptoms develop
- Improved contrast
- Improved targeting

NanoCeramics

Technology Emphasis:

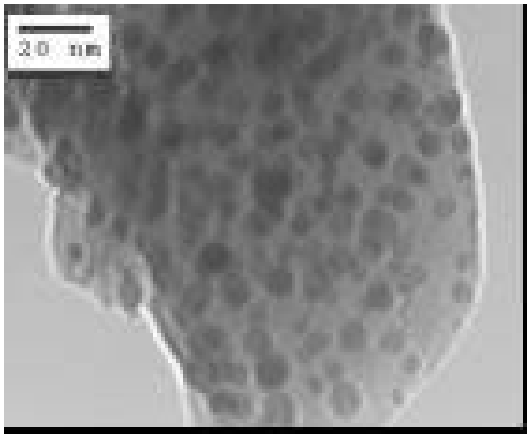
Bioinspired Materials

- Increased Toughness
- Contained Damage



NanoCeramic Synthesis

- Templating and Self-Assembly

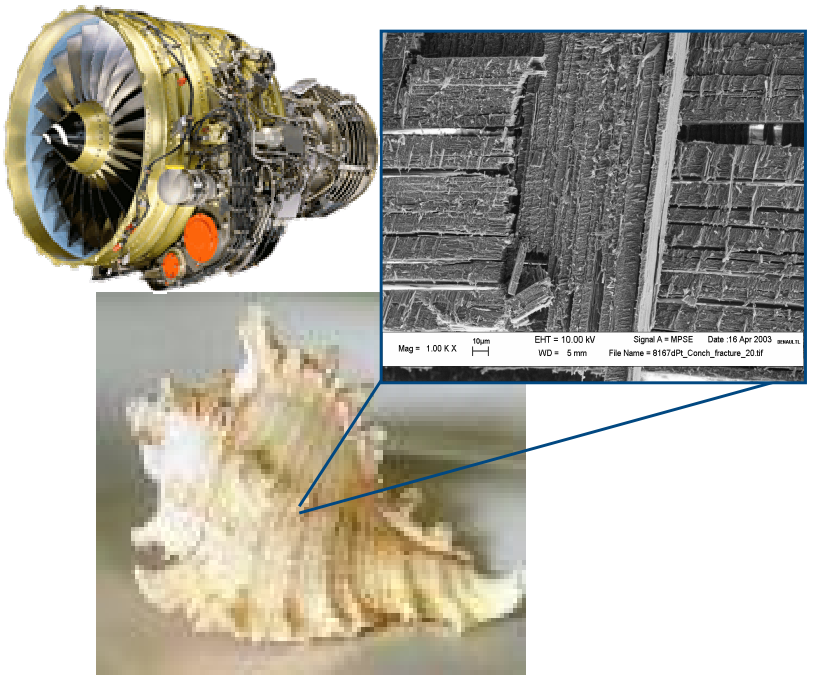


1500°C, 8 hours

High Temperature Stability

NanoCeramics

Product Impact:

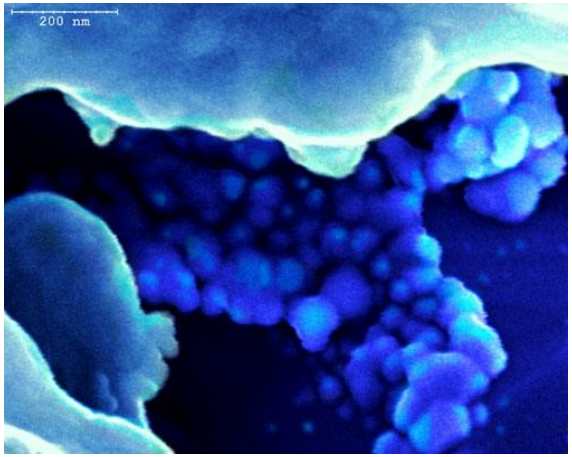


More Damage Tolerant Ceramics

- Power Generation & Aircraft Engines
- Improved efficiency: higher temp, lighter weight

NanoPhosphors

- Improved effiency lighting



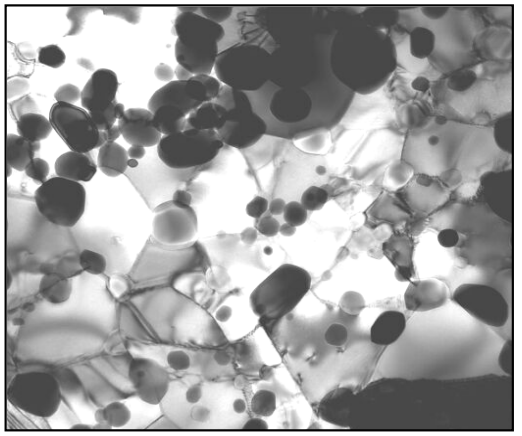
Harsh Environment Sensors

Nanostructured Metallic Systems

Technology Emphasis:

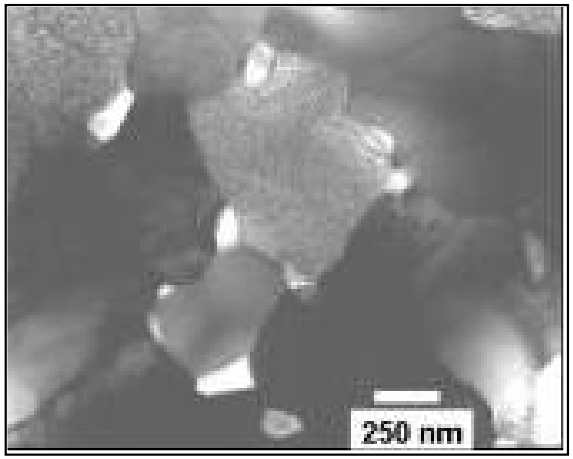
High-Strength Alloys

- Novel processes to create nanostructures
- Structure-property relationships



High-Temperature Stability

- Create mechanisms to prevent coarsening of nanostructures
- Computational modeling



Nanostructured Metallic Systems

Product Impact:

Aircraft Engines

- Weight reduction in fan blades
- Improved efficiency

Electric Power

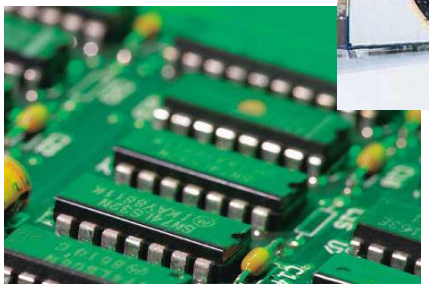
- High power density machines

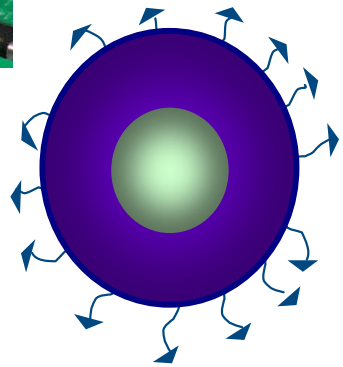
High Efficiency Power Turbines

- Higher operating temperatures
- Improved life

GE Nanotechnology Driving Growth

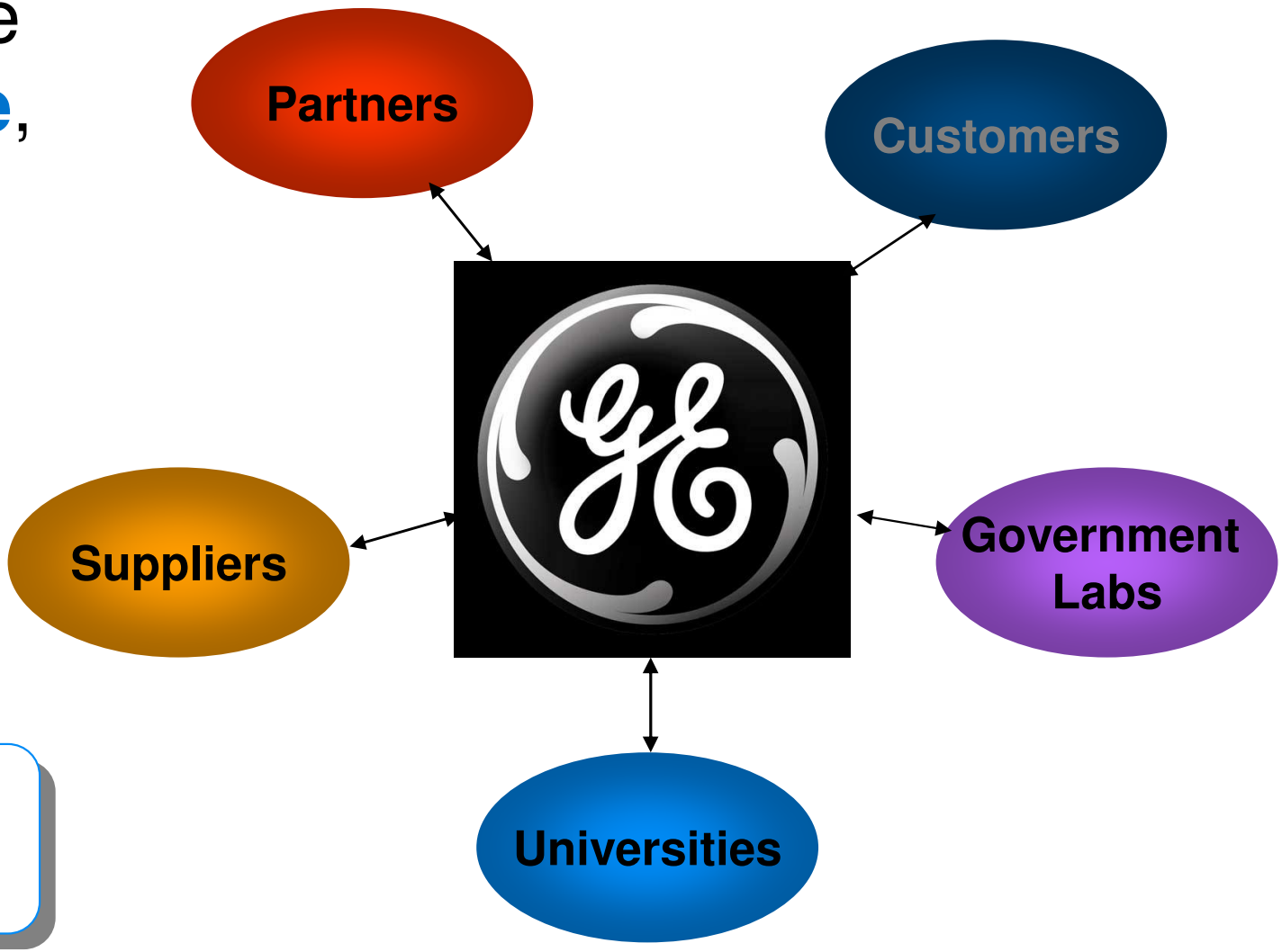
- Building on 100 years of material science expertise
- Creating breakthroughs in material properties
- Will impact all GE businesses
- Expand into new markets
- Create new products and services





But Even GE Needs Partners

In order to move **fast**, be **flexible**, and keep **costs** down, GE must **strategically partner**….



Partnership must be win-win

Strategic Alliances at GE GR

GE's overall strategy for partnering:

- **When?**
  - a technology gap exists at GE
  - makes sense for all partners

- **How?**
  - use six sigma for partner selection
  - method (JV, government funding, direct funding, etc.) is on case-by-case basis

- **What works?**
  - it's a win-win for everyone
  - roles and goals are well defined
  - IP ownership agreed-to early

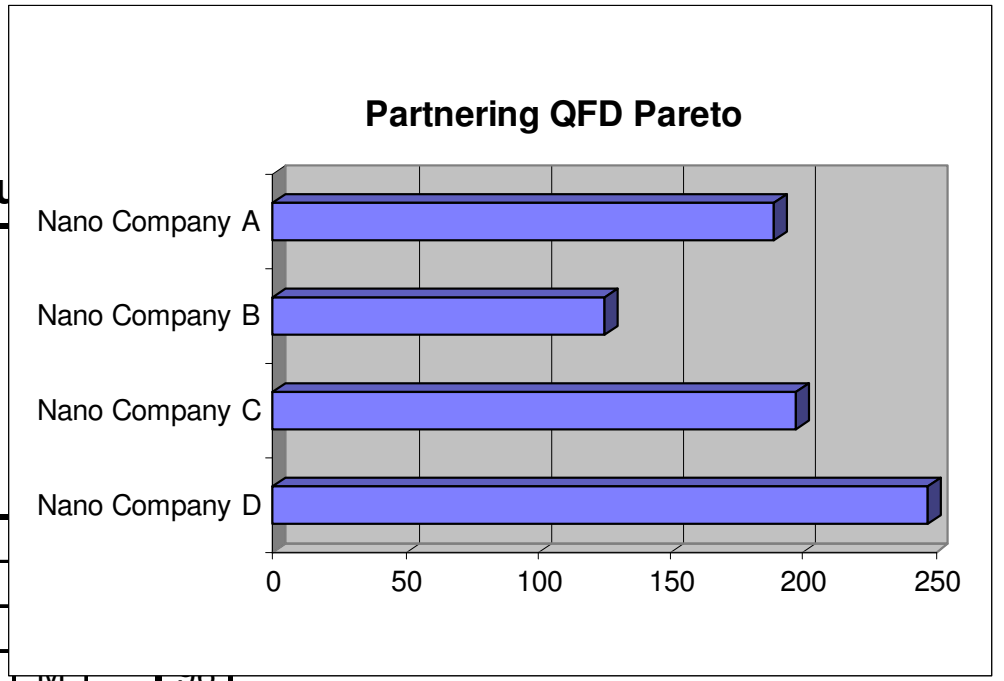
Partner Selection Is Critical

Use Six Sigma tools to help select partner — *Partner tradeoff analysis using QFD*

Partnering QFD

Product Requ

Customer Expectation	Importance	Nano Company A	Nano Company B	Nano Company C			
Synergy with CNT growth technology	4	H	L	M			
No End Use Conflict	5	M	L	H			
Potential IP clash (no current strategy with anyc	5	H	L	H			
Responsiveness	4	M	H	H	M		96
Well-known technical lead	3	M	H	L	H		66
Synergy with company's charter	3	M	M	H	H		72
Timing - close within 1 week	5	M	M	L	M		50
Synergy with device technology	5	H	M	M	H		120
Compatible Business Model	3	L	M	M	H		48
Total		189	125	197	247		



Nanotechnology AT

Ready to Serve

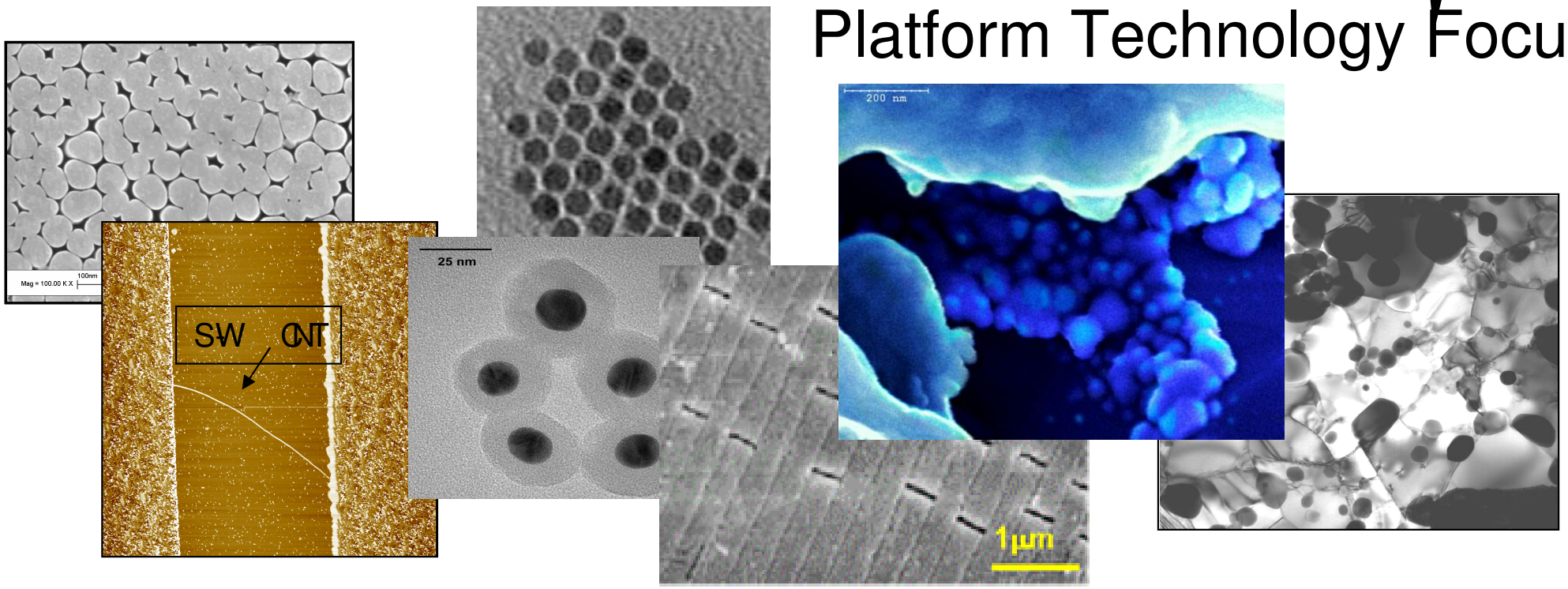
Multi-Generation Product Plans

CEO Projects

Advanced Technology

5-10+ years to impact Business

Platform Technology Focus



NanoTubes and NanoRods / NanoParticles / NanoCeramics / NanoStructured Metal Systems

imagination at work